



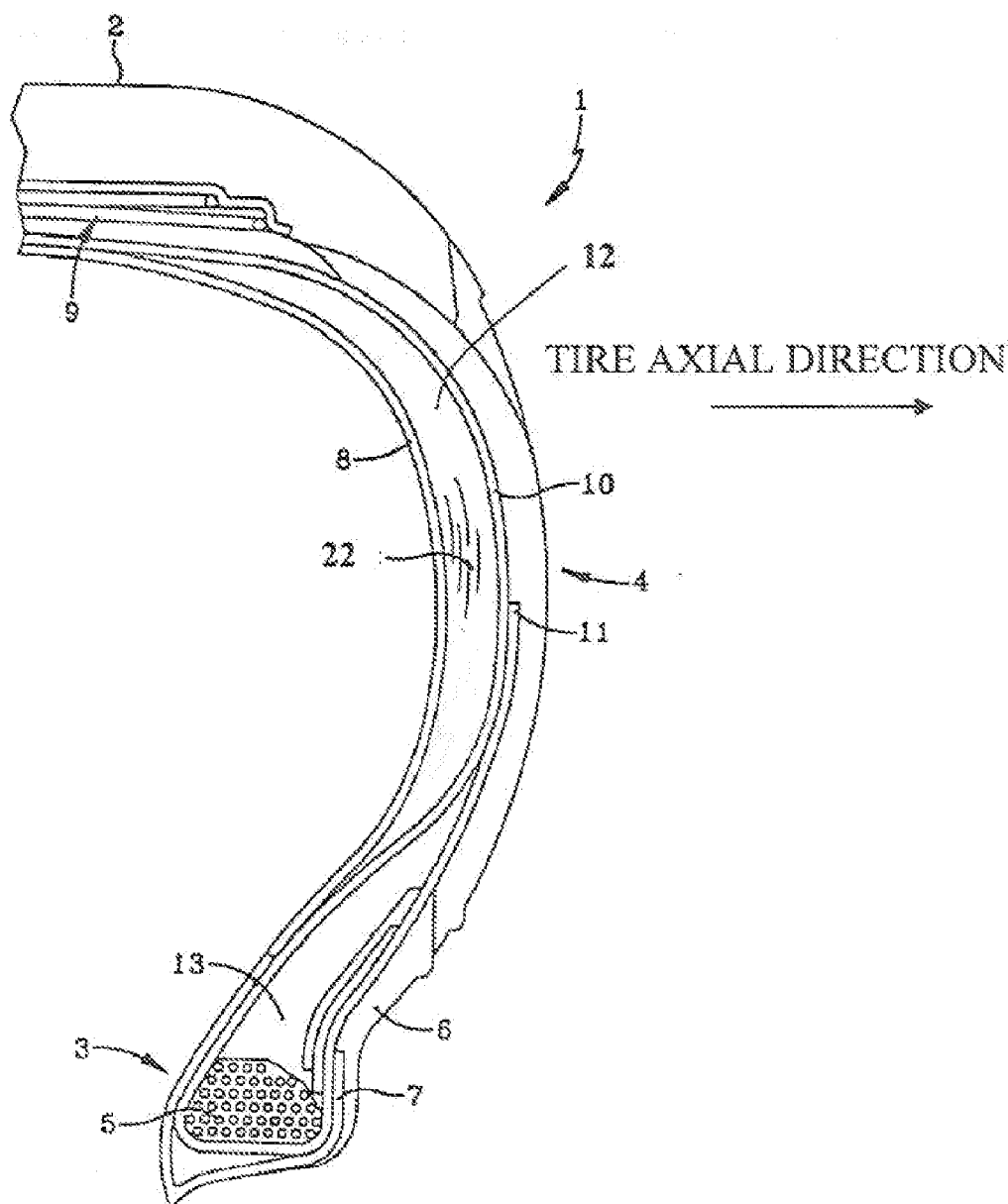
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(19) **United States**(12) **Patent Application Publication**
Mruk et al.(10) **Pub. No.: US 2012/0234450 A1**(43) **Pub. Date: Sep. 20, 2012**(54) **RUNFLAT TIRE WITH THERMOPLASTIC
SIDEWALL INSERT****Publication Classification**(51) **Int. Cl.***B60C 17/00* (2006.01)*B29D 30/10* (2006.01)(52) **U.S. Cl. 152/517; 156/123; 156/110.1**

(57)

ABSTRACT

The invention is directed to a pneumatic runflat tire comprising a sidewall insert, the sidewall insert comprising an axially layered thermoplastic.

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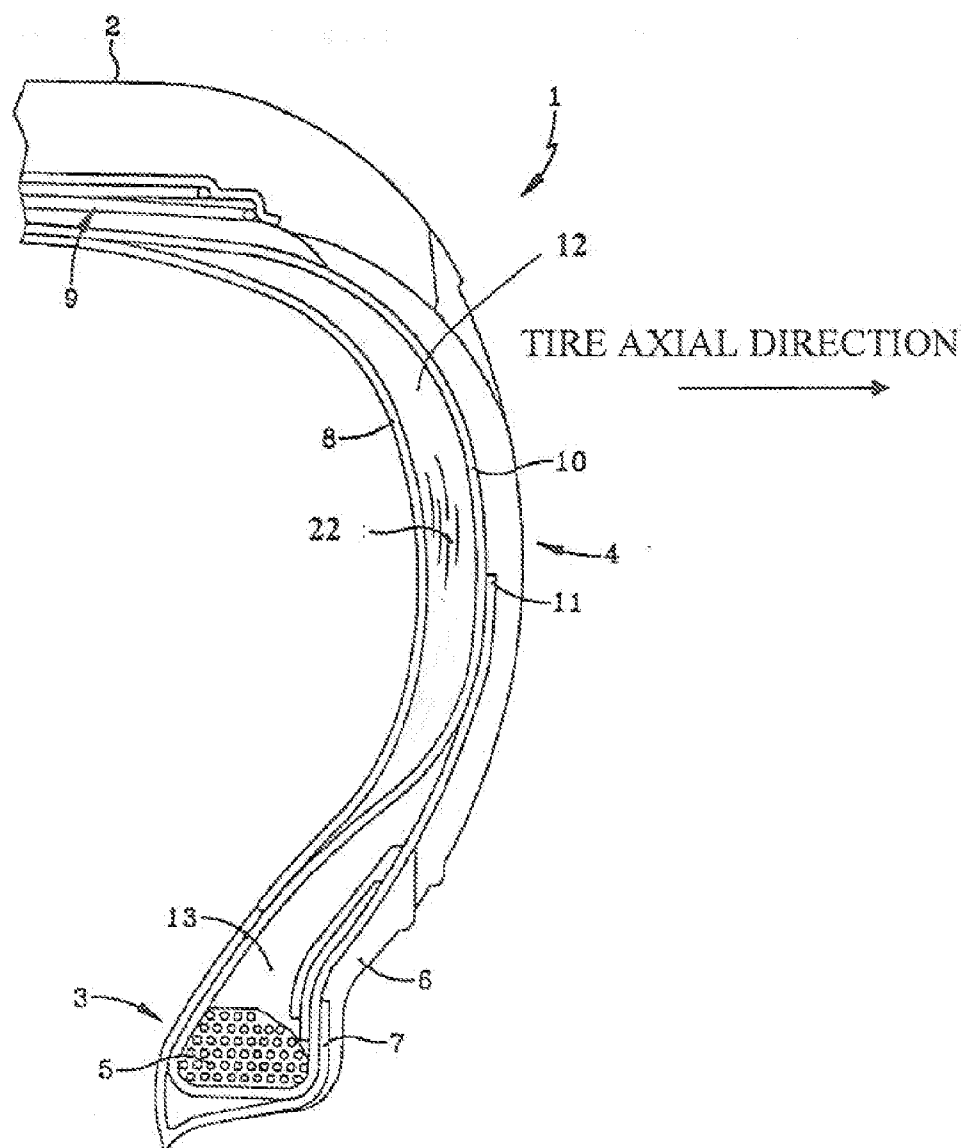


FIG-1

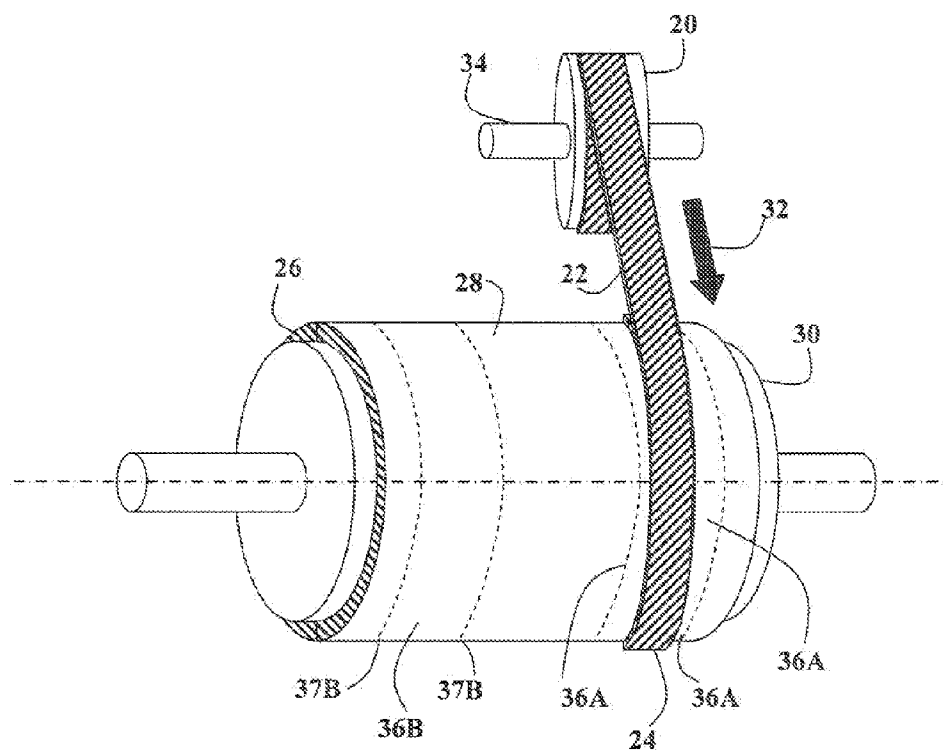


FIG - 2

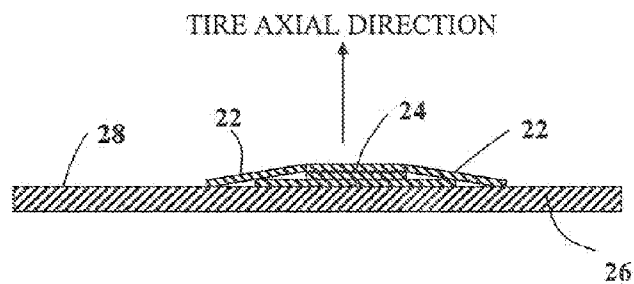


FIG - 3

RUNFLAT TIRE WITH THERMOPLASTIC SIDEWALL INSERT

BACKGROUND OF THE INVENTION

[0001] The desire for improved fuel efficiency in automobiles, trucks, aircraft and the like has led to the need for more fuel efficient tires. One way in which tires can be more fuel efficient is through reduced weight of the tires. It is therefore desirable to reduce the weight of tires while maintaining the physical properties and performance of the various tire components.

SUMMARY OF THE INVENTION

[0002] The present invention is directed to a pneumatic runflat tire comprising a sidewall insert, the sidewall insert comprising an axially layered thermoplastic.

[0003] The invention is further directed to a method of making a pneumatic runflat tire, comprising the steps of

[0004] applying one or more tire components to a tire building machine; and

[0005] applying a plurality of layers of a thermoplastic to the one or more components to form an axially-layered thermoplastic runflat insert.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 is a fragmentary cross-sectional view of a tire showing its tread and carcass with one ply and one insert axially inward of the ply in the sidewall region of the tire as an embodiment of the invention.

[0007] FIG. 2 is schematic representation of a method of making a runflat tire according to the present invention.

[0008] FIG. 3 is cross section of a partially built runflat insert.

DETAILED DESCRIPTION OF THE INVENTION

[0009] There is disclosed a pneumatic runflat tire comprising a sidewall insert, the sidewall insert comprising an axially layered thermoplastic.

[0010] There is further disclosed a method of making a pneumatic runflat tire, comprising the steps of

[0011] applying one or more tire components to a tire building machine; and

[0012] applying a plurality of layers of a thermoplastic to the one or more components to form an axially-layered thermoplastic runflat insert.

[0013] Tires containing the thermoplastic runflat inserts of this invention can be comprised of a toroidally-shaped carcass and an outer, circumferential tread designed to be ground-contacting, wherein said carcass is comprised of two spaced-apart inextensible bead portions, two spaced-apart sidewalls each individually extending radially inward from and connecting said tread to said bead portions and at least one cord reinforced ply extending from bead to bead and through the sidewalls; an improvement in which a substantially crescent-shaped rubber insert is juxtapositioned to and axially inward of at least one of said carcass plies in each of said sidewalls of the tire.

[0014] So constructed, the runflat tire with a thermoplastic insert is lighter than prior art runflat tires with conventional inserts made of compounded rubber. Such rubber inserts have a high carbon black content to ensure a sufficient stiffness to

support a tire during a deflation episode. By contrast, a runflat tire with a thermoplastic insert has sufficient stiffness, but at lower overall tire weight.

[0015] Preferably, the insert has a maximum thickness at a location about midway between the bead portions and the tread in the sidewall region of the tire.

[0016] In the practice of this invention, a significant function of the insert in the sidewall portion of the tire is to stiffen/support the sidewall structure when the tire is operated without inflation pressure.

[0017] The shape of the insert is described as being substantially crescent in shape. This is intended to also include an entrunkated crescent shape, particularly where the entrunkated portion of the crescent-shaped insert is juxtapositioned to the tire's bead portion.

[0018] In further practice of the invention, said tire carcass may have from one to three plies comprised of a first axially inner ply and optionally one or two additional plies as a second ply and third ply, respectively; each additional ply positioned sequentially axially outward from said first ply in the sidewall region of the tire.

[0019] Accordingly, in accordance with this invention, said tire contains one ply in its carcass wherein said insert is juxtapositioned to and axially inward of said ply in the sidewall region of the tire.

[0020] In further accordance with this invention, said tire contains, in its carcass, an axially inner first ply and a second ply axially outward from the first ply; wherein said insert is juxtapositioned to and axially inward of said first ply, in the sidewall region of the tire.

[0021] In additional accordance with this invention, said tire contains, in its carcass, an axially inner first ply and an axially outer second ply; wherein said insert is juxtapositioned to and interposed between said first and second ply, in the sidewall region of the tire.

[0022] In further accordance with this invention, said tire contains, in its carcass, an axially inner first ply and an axially outer second ply; wherein one of said inserts is juxtapositioned to and interposed between said first and second ply, in the sidewall region of the tire, and another of said inserts is juxtapositioned to and axially inward of said first ply, in the sidewall region of the tire.

[0023] In further accordance with this invention, said tire contains, in its carcass, an axially inner first ply, a second ply axially outward from said first ply and a third ply axially outward from said second ply; wherein said insert is juxtapositioned to and axially inward of said first ply, in the sidewall region of the tire.

[0024] In additional accordance with this invention, said tire contains, in its carcass, an axially inner first ply, a second ply axially outward from said first ply and a third ply axially outward from said second ply; wherein said insert is juxtapositioned to and interposed between (a) said first and second plies and/or (b) said second and third plies, in the sidewall region of the tire.

[0025] In further accordance with this invention, said tire contains, in its carcass, an axially inner first ply, a second ply axially outward from said first ply and a third ply axially outward from said second ply; wherein said insert is juxtapositioned to and interposed between (a) said first and second plies and/or (b) said second and third plies, in the sidewall region of the tire and, also, an insert juxtapositioned to and axially inward of the innermost of said plies.

[0026] In one embodiment, the innermost ply, or plies, has synthetic or textile cord reinforcement of polyester, nylon, rayon or aramid, preferably nylon; while the outermost ply preferably has aramid, rayon, carbon fiber, fiberglass or metal cord reinforcement, preferably brass and/or zinc-coated steel cords.

[0027] Thus, in a preferred embodiment, the first ply has reinforcing cords of rayon and the second and additional plies are cords of rayon.

[0028] In one aspect, the outermost ply preferably has cords of a higher modulus (i.e., steel cords) and the innermost ply, or plies, have cords of a lower modulus (i.e., nylon or rayon).

[0029] At least one ply, preferably the innermost ply, extended from bead core to bead cord and wraps around the bead core. Alternatively, where two or more plies are used, at least one of the additional plies, while extending from bead core to bead core, does not actually wrap around the bead core.

[0030] Referring to the drawings, FIG. 1 shows the fragmentary cross-section of a runflat tire 1, its tread 2, bead portion 3, sidewall or sidewall region 4, inextensible wire bead core 5, rubber chafer 6, rubber toeguard 7, rubber composition innerliner 8, belt structure 9 underlying a portion of the tread 2, carcass ply 10, carcass ply turnup 11, thermoplastic insert 12 and apex 13. Thermoplastic insert 12 comprises axially-layered thermoplastic layers 22, as will be discussed in more detail. A similar construction is used on the section of the tire opposite the radial centerline of the tire (not shown).

[0031] The cords for use in the carcass plies may comprise from one (monofilament) to multiple twisted filaments. The number of total filaments in the cord may range from 1 to 13. The cords, particularly metallic cords, of the carcass ply are generally oriented such that the tire according to the present invention is what is commonly referred to as a radial.

[0032] The cords of the carcass ply intersect the equatorial plane (EP) of the tire at an angle in the range of from 75° to 105°. Preferably, the cords intersect at an angle of from 82° to 98°. A more preferred range is from 89° to 91°.

[0033] The first and second reinforcing ply structure each may comprise a single ply layer; however, any number of carcass plies may be used. As further illustrated in FIG. 1, the first ply structure has a pair of turnup ends respectively which wrap about each bead core 5 of the bead portion 3 of the carcass. The ends 11 of ply 10 are in proximity to the bead core 5 and terminate radially adjacent on either side of the bead core 5, above the bead core 5 or can be wrapped around the bead core 5 and terminates radially below the turnup end 11 of ply 10 as shown. The turnup ends 11 of ply 10 wrap about the second ply ends and the bead core 5. The turnup ends of the first ply 11 terminates radially a distance above the nominal rim diameter of the tire 1 in proximity to the radial location of the maximum section width of the tire. In a preferred embodiment, the turnup ends are located within 20 percent of the section height of the tire from the radial location of the maximum section width, most preferably terminating at the radial location of the maximum section width.

[0034] The bead core 5 is preferably constructed of a single or monofilament steel wire continuously wrapped. Located within the bead region 3 and the radially inner portions of the sidewall portions 4 are high modulus elastomeric apex inserts disposed between ply 10 and the turnup ends 11, respectively. The apex 13 extends from the radially outer portion of bead

portions respectively, up into the sidewall portion gradually decreasing in cross-sectional width. The apex 13 terminates at a radially outer end.

[0035] The insert 12 may extend from each bead region radially to the edge of the tread, usually to just beneath the reinforcing belt structures 9. As illustrated in FIG. 1, the sidewall portions include a thermoplastic insert 12. Additional inserts (not shown) may be included between additional plies (not shown).

[0036] In one embodiment, the inserts 12 each have a thickness at its maximum thickness of at least three percent of the maximum section height "SR" at a location approximately radially aligned to the maximum section width of the tire.

[0037] The overall cross-sectional thickness of the combination of elastomeric inserts preceding from the bead portions to the radial location of the maximum section width (SW) is preferably of constant thickness. The overall sidewall and carcass thickness is at least 0.45 inches (11.5 mm) at the maximum section width location and increases to an overall thickness in the region where it merges into the shoulder near the lateral tread edges. Preferably, the overall thickness of the sidewall in the shoulder region of the tire is at least one hundred percent (100%) of the overall sidewall thickness at the maximum section width (SW). This ratio means that the sidewall can be made substantially thinner than the predecessor-type runflat tires.

[0038] As previously discussed, the tire of the present invention has at least one ply having a turnup end 11 (wrapped around the bead core 5) while another ply can simply be terminated adjacent to the bead core 5 without actually wrapping around the bead core 5.

[0039] The insert 12 is made of thermoplastic material. The insert 12 is designed to prevent the tire's sidewall from collapsing when operating under no inflation pressure. The material shape and cross-sectional profile is modified to insure the ride performance and sidewall spring rate is acceptable. The cross-sectional area of the insert can be reduced without compromising performance characteristics by utilizing stiffer materials in the insert. Thus, weight can be reduced by using stiffer thermoplastic materials in the insert.

[0040] The second insert and third insert, if used, can be of the same or different material physical properties relative to the first insert 12. This means that the combination of a hard second insert, and/or third insert, if used, with a softer first insert 12 is contemplated as well as the combination of a hard first insert 12 with a softer second and/or third insert.

[0041] The second insert and third insert, if used, are made of thermoplastic or elastomeric material. These inserts can be used in multiples of inserts interposed between adjacent plies when more than two plies are used in the carcass structure.

[0042] The second and third inserts, when used, act as a spacer between the adjacent plies. The cords of the plies particularly the radially outer ply is placed in tension when the tire is operated uninflated.

[0043] In practice, the compositions for the inserts utilized in this invention for the aforesaid pneumatic tire construction are preferably characterized by physical properties which enhance their utilization in the invention which are, collectively, believed to be a departure from properties of conventional rubber compositions normally used in pneumatic tire sidewalls, particularly the combination of inserts 12 and with plies 10 having a combination of either dissimilar or similar high stiffness yet essentially low hysteresis properties.

[0044] In particular, for the purposes of this invention, the aforesaid inserts **12** are designed to have a high degree of stiffness yet also having lower weight than for an inserts not containing the thermoplastic.

[0045] The thermoplastic inserts are constructed from multiple, relatively thin layers of thermoplastic material. In one embodiment, the thermoplastic layers have a thickness in a range of 0.1 to 1 mm (4 to 40 mils). The multiple layers of thermoplastic are layered sequentially in such a way as to form the desired cross-sectional thicknesses and shape suitable for used as a runflat insert. The multiple layers of thermoplastic may be layered using manual or automatic (continuous) methods.

[0046] In one embodiment, the thermoplastic insert is constructed using a method as illustrated in FIG. 2. In FIG. 2, innerliner material **26** (corresponding to the innerliner **8** in FIG. 1) has been built onto tire drum **30**. Thermoplastic material in the form of a continuous tape **22** is transferred onto surface **28** of innerliner material **26** by unwinding from spool **20** in the direction of arrow **32**. Tape **22** is layered to form partially built insert **24** by sequential application of tape **22** during rotation of tire drum **30** and spool **20**. Insert regions **36A,B** are indicated by the areas between the dashed lines **37A** and **37B**, respectively. Tape **22** is disposed in regions **36A,B** of surface **28**; regions **36** correspond to the desired location of the inserts **12** (FIG. 1).

[0047] A partially built insert **24** is shown in cross-section in FIG. 3, with a plurality of layers of tape **22** disposed on surface **28** of innerliner material **26** after sequential rotations of tire drum **30**. As is evident from FIG. 3, the various layers of tape **22** are stacked and overlapped in such a manner as to form the desired cross-sectional thicknesses and shape of the partially built insert **24**. The relative overlap of sequential layers of tape **22** may be controlled by indexing spool **20** along its axle **34**.

[0048] Upon completion of the desired shaped of partially built insert **24**, tape **22** is cut from spool **20**. The remaining tire components (sidewall, beads, tread, etc., not shown) are built onto the tire building drum **30** in the conventional manner. Upon removal of the built green tire from the tire drum **30** and formation into the conventional toroidal conformation as depicted in partial cross-section in FIG. 1, the layers of tape **22** are seen to be axially-layered with respect to the axial direction of the tire **1**. The layers of tape **22** are fused by application of heat during cure of tire **1** to form insert **12**, or by action of an adhesive applied to tape **22**.

[0049] The construction of insert **12** from thermoplastic tape layers **22** facilitates use of a thermoplastic insert in a runflat tire. Construction of a thermoplastic insert from a monolithic, preshaped thermoplastic insert material is difficult due to the high modulus of the material. Bending such a monolithic material for use during tire building requires thermal softening of the thermoplastic, which adds a level of complexity in processing and operator handling due to the high temperature. With the present method, the relatively thin tape **22** allows easy handling and application of the thermoplastic during tire building without need for thermal softening.

[0050] The insert **12** comprises a plurality of axially layered thermoplastic layers. In one embodiment, the insert comprises at least 10 axially layered thermoplastic layers.

[0051] Suitable thermoplastic materials for use as the tape **22** and insert **12** include polyolefin such as polyethylene and polypropylene; polyamides such as nylon 6, nylon 6,6; nylon

6,12; polyesters such as polyethylene terephthalate (PET) and polybutylene terephthalate (PBT); polyphenylene ether (PPE); polyphthalamide (PPA); and the like. Suitable thermoplastics will have a melting temperature greater than the temperatures experienced during a runflat event by the tire. In one embodiment, the thermoplastic has a melting temperature greater than 160° C. In one embodiment, the thermoplastic has a melting temperature greater than 130° C.

[0052] The thermoplastic material may be treated on its surface with an adhesive to promote adhesion between the layers of tape **22** and the adhesion between the tape **22** and adjacent rubber components of the tire. In one embodiment, the tape **22** is dipped in an RFL (resorcinol-formaldehyde-latex) type adhesive as is known in the rubber compounding art. In one embodiment, the tape **22** is dipped in an epoxy-based adhesive. In one embodiment, the tape **22** is dipped in a combination of RFL and epoxy-based adhesives. The adhesive, if used, is then disposed between the layers of tape **22** in the insert **12**.

[0053] The tire components other than the thermoplastic insert, such as tread, sidewalls, etc., may be made from rubber compositions with rubbers or elastomers containing olefinic unsaturation. The phrase "rubber or elastomer containing olefinic unsaturation" is intended to include both natural rubber and its various raw and reclaim forms as well as various synthetic rubbers. In the description of this invention, the terms "rubber" and "elastomer" may be used interchangeably, unless otherwise prescribed. The terms "rubber composition," "compounded rubber" and "rubber compound" are used interchangeably to refer to rubber which has been blended or mixed with various ingredients and materials and such terms are well known to those having skill in the rubber mixing or rubber compounding art. Representative synthetic polymers are the homopolymerization products of butadiene and its homologues and derivatives, for example, methylbutadiene, dimethylbutadiene and pentadiene as well as copolymers such as those formed from butadiene or its homologues or derivatives with other unsaturated monomers. Among the latter are acetylenes, for example, vinyl acetylene; olefins, for example, isobutylene, which copolymerizes with isoprene to form butyl rubber; vinyl compounds, for example, acrylic acid, acrylonitrile (which polymerize with butadiene to form NBR), methacrylic acid and styrene, the latter compound polymerizing with butadiene to form SBR, as well as vinyl esters and various unsaturated aldehydes, ketones and ethers, e.g., acrolein, methyl isopropenyl ketone and vinyl-ethyl ether. Specific examples of synthetic rubbers include neoprene (polychloroprene), polybutadiene (including cis-1,4-polybutadiene), polyisoprene (including cis-1,4-polyisoprene), butyl rubber, halobutyl rubber such as chlorobutyl rubber or bromobutyl rubber, styrene/isoprene/butadiene rubber, copolymers of 1,3-butadiene or isoprene with monomers such as styrene, acrylonitrile and methyl methacrylate, as well as ethylene/propylene terpolymers, also known as ethylene/propylene/diene monomer (EPDM), and in particular, ethylene/propylene/dicyclopentadiene terpolymers. Additional examples of rubbers which may be used include alkoxy-silyl end functionalized solution polymerized polymers (SBR, PBR, IBR and SIBR), silicon-coupled and tin-coupled star-branched polymers. The preferred rubber or elastomers are polybutadiene and SBR.

[0054] In one aspect the rubber is preferably of at least two of diene based rubbers. For example, a combination of two or more rubbers is preferred such as cis 1,4-polyisoprene rubber

(natural or synthetic, although natural is preferred), 3,4-polyisoprene rubber, styrene/isoprene/butadiene rubber, emulsion and solution polymerization derived styrene/butadiene rubbers, cis 1,4-polybutadiene rubbers and emulsion polymerization prepared butadiene/acrylonitrile copolymers.

[0055] In one aspect of this invention, an emulsion polymerization derived styrene/butadiene (E-SBR) might be used having a relatively conventional styrene content of about 20 to about 28 percent bound styrene or, for some applications, an E-SBR having a medium to relatively high bound styrene content, namely, a bound styrene content of about 30 to about 45 percent.

[0056] By emulsion polymerization prepared E-SBR, it is meant that styrene and 1,3-butadiene are copolymerized as an aqueous emulsion. Such are well known to those skilled in such art. The bound styrene content can vary, for example, from about 5 to about 50 percent. In one aspect, the E-SBR may also contain acrylonitrile to form a terpolymer rubber, as E-SBAR, in amounts, for example, of about 2 to about 30 weight percent bound acrylonitrile in the terpolymer.

[0057] Emulsion polymerization prepared styrene/butadiene/acrylonitrile copolymer rubbers containing about 2 to about 40 weight percent bound acrylonitrile in the copolymer are also contemplated as diene based rubbers for use in this invention.

[0058] The solution polymerization prepared SBR (S-SBR) typically has a bound styrene content in a range of about 5 to about 50, preferably about 9 to about 36, percent. The S-SBR can be conveniently prepared, for example, by organo lithium catalyzation in the presence of an organic hydrocarbon solvent.

[0059] In one embodiment, cis 1,4-polybutadiene rubber (BR) may be used. Such BR can be prepared, for example, by organic solution polymerization of 1,3-butadiene. The BR may be conveniently characterized, for example, by having at least a 90 percent cis 1,4-content.

[0060] The cis 1,4-polyisoprene and cis 1,4-polyisoprene natural rubber are well known to those having skill in the rubber art.

[0061] The term “phr” as used herein, and according to conventional practice, refers to “parts by weight of a respective material per 100 parts by weight of rubber, or elastomer.”

[0062] The rubber composition may also include up to 70 phr of processing oil. Processing oil may be included in the rubber composition as extending oil typically used to extend elastomers. Processing oil may also be included in the rubber composition by addition of the oil directly during rubber compounding. The processing oil used may include both extending oil present in the elastomers, and process oil added during compounding. Suitable process oils include various oils as are known in the art, including aromatic, paraffinic, naphthenic, vegetable oils, and low PCA oils, such as MES, TDAE, SRAE and heavy naphthenic oils.

[0063] Suitable low PCA oils include those having a polycyclic aromatic content of less than 3 percent by weight as determined by the IP346 method. Procedures for the IP346 method may be found in *Standard Methods for Analysis & Testing of Petroleum and Related Products* and *British Standard 2000 Parts*, 2003, 62nd edition, published by the Institute of Petroleum, United Kingdom.

[0064] The phrase “rubber or elastomer containing olefinic unsaturation” is intended to include both natural rubber and its various raw and reclaim forms as well as various synthetic rubbers. In the description of this invention, the terms “rub-

ber” and “elastomer” may be used interchangeably, unless otherwise prescribed. The terms “rubber composition,” “compounded rubber” and “rubber compound” are used interchangeably to refer to rubber which has been blended or mixed with various ingredients and materials, and such terms are well known to those having skill in the rubber mixing or rubber compounding art.

[0065] The vulcanizable rubber composition may include from about 10 to about 150 phr of silica.

[0066] The commonly employed siliceous pigments which may be used in the rubber compound include conventional pyrogenic and precipitated siliceous pigments (silica). In one embodiment, precipitated silica is used. The conventional siliceous pigments employed in this invention are precipitated silicas such as, for example, those obtained by the acidification of a soluble silicate, e.g., sodium silicate.

[0067] Such conventional silicas might be characterized, for example, by having a BET surface area, as measured using nitrogen gas. In one embodiment, the BET surface area may be in the range of about 40 to about 600 square meters per gram. In another embodiment, the BET surface area may be in a range of about 80 to about 300 square meters per gram. The BET method of measuring surface area is described in the *Journal of the American Chemical Society*, Volume 60, Page 304 (1930).

[0068] The conventional silica may also be characterized by having a dibutylphthalate (DBP) absorption value in a range of about 100 to about 400, alternatively about 150 to about 300.

[0069] The conventional silica might be expected to have an average ultimate particle size, for example, in the range of 0.01 to 0.05 micron as determined by the electron microscope, although the silica particles may be even smaller, or possibly larger, in size.

[0070] Various commercially available silicas may be used, such as, only for example herein, and without limitation, silicas commercially available from PPG Industries under the Hi-Sil trademark with designations 210, 243, etc.; silicas available from Rhodia, with, for example, designations of Z1165MP and Z165GR and silicas available from Degussa AG with, for example, designations VN2 and VN3, etc.

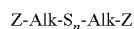
[0071] The vulcanizable rubber composition may include from 1 to 100 phr of carbon black, crosslinked particulate polymer gel, ultra high molecular weight polyethylene (UHMWPE) or plasticized starch.

[0072] Commonly employed carbon blacks can be used as a conventional filler. Representative examples of such carbon blacks include N110, N121, N134, N220, N231, N234, N242, N293, N299, N315, N326, N330, N332, N339, N343, N347, N351, N358, N375, N539, N550, N582, N630, N642, N650, N683, N754, N762, N765, N774, N787, N907, N908, N990 and N991. These carbon blacks have iodine absorptions ranging from 9 to 145 g/kg and DBP number ranging from 34 to 150 cm³/100 g.

[0073] Other fillers may be used in the rubber composition including, but not limited to, particulate fillers including ultra high molecular weight polyethylene (UHMWPE), particulate polymer gels including but not limited to those disclosed in U.S. Pat. Nos. 6,242,534; 6,207,757; 6,133,364; 6,372,857; 5,395,891; or 6,127,488, and plasticized starch composite filler including but not limited to that disclosed in U.S. Pat. No. 5,672,639.

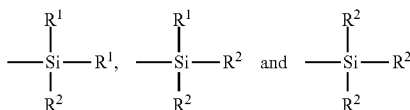
[0074] In one embodiment the rubber composition for use in the tire tread may contain a conventional sulfur containing

organosilicon compound. Examples of suitable sulfur containing organosilicon compounds are of the formula:



II

in which Z is selected from the group consisting of

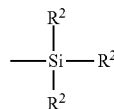


where R¹ is an alkyl group of 1 to 4 carbon atoms, cyclohexyl or phenyl; R² is alkoxy of 1 to 8 carbon atoms, or cycloalkoxy of 5 to 8 carbon atoms; Alk is a divalent hydrocarbon of 1 to 18 carbon atoms and n is an integer of 2 to 8.

[0075] Specific examples of sulfur containing organosilicon compounds which may be used in accordance with the present invention include: 3,3'-bis(trimethoxysilylpropyl) disulfide, 3,3'-bis(triethoxysilylpropyl)disulfide, 3,3'-bis(triethoxysilylpropyl)tetrasulfide, 3,3'-bis(triethoxysilylpropyl) octasulfide, 3,3'-bis(trimethoxysilylpropyl)tetrasulfide, 2,2'-bis(triethoxysilylpropyl)tetrasulfide, 3,3'-bis(trimethoxysilylpropyl)trisulfide, 3,3'-bis(triethoxysilylpropyl)trisulfide, 3,3'-bis(tributoxysilylpropyl)disulfide, 3,3'-bis(trimethoxysilylpropyl)hexasulfide, 3,3'-bis(trimethoxysilylpropyl)octasulfide, 3,3'-bis(trioctoxysilylpropyl)tetrasulfide, 3,3'-bis(triethoxysilylpropyl)disulfide, 3,3'-bis(triethoxysilylpropyl)trisulfide, 3,3'-bis(ethylhexoxysilylpropyl)trisulfide, 3,3'-bis(triisooctoxysilylpropyl)tetrasulfide, 3,3'-bis(tri-*t*-butoxysilylpropyl)disulfide, 2,2'-bis(methoxy diethoxy silyl ethyl)tetrasulfide, 2,2'-bis(tripropoxysilylpropyl)pentasulfide, 3,3'-bis(tricyclonoxysilylpropyl)tetrasulfide, 3,3'-bis(tricyclopentoxysilylpropyl)trisulfide, 2,2'-bis(tri-2"-methylcyclohexoxysilylpropyl)tetrasulfide, bis(trimethoxysilylmethyl) tetrasulfide, 3-methoxy ethoxy propoxysilyl 3'-diethoxybutoxy-silylpropyltetrasulfide, 2,2'-bis(dimethyl methoxysilylpropyl)disulfide, 2,2'-bis(dimethyl sec.butoxysilylpropyl)trisulfide, 3,3'-bis(methyl butylethoxysilylpropyl) tetrasulfide, 3,3'-bis(di-*t*-butylmethoxysilylpropyl)tetrasulfide, 2,2'-bis(phenyl methyl methoxysilylpropyl)trisulfide, 3,3'-bis(diphenyl isopropoxysilylpropyl)tetrasulfide, 3,3'-bis(diphenyl cyclohexoxysilylpropyl)disulfide, 3,3'-bis(dimethyl ethylmercaptosilylpropyl)tetrasulfide, 2,2'-bis(methyl dimethoxysilylpropyl)trisulfide, 2,2'-bis(methyl ethoxypropoxysilylpropyl)tetrasulfide, 3,3'-bis(diethyl methoxysilylpropyl)tetrasulfide, 3,3'-bis(ethyl di-sec. butoxysilylpropyl)disulfide, 3,3'-bis(propyl diethoxysilylpropyl)disulfide, 3,3'-bis(butyl dimethoxysilylpropyl)trisulfide, 3,3'-bis(phenyl dimethoxysilylpropyl)tetrasulfide, 3-phenyl ethoxybutoxysilyl 3'-trimethoxysilylpropyl tetrasulfide, 4,4'-bis(trimethoxysilylbutyl)tetrasulfide, 6,6'-bis(triethoxysilylhexyl)tetrasulfide, 12,12'-bis(triisopropoxysilyldodecyl)disulfide, 18,18'-bis(trimethoxysilyloctadecyl)tetrasulfide, 18,18'-bis(tripropoxysilyloctadecyl)tetrasulfide, 4,4'-bis(trimethoxysilyl-*n*-buten-2-yl)tetrasulfide, 4,4'-bis(trimethoxysilylcyclohexylene)tetrasulfide, 5,5'-bis(dimethoxymethylsilylpropyl)trisulfide, 3,3'-bis(trimethoxysilyl-2-methylpropyl)tetrasulfide, 3,3'-bis(dimethoxyphenylsilyl-2-methylpropyl)disulfide.

[0076] In one embodiment, the sulfur containing organosilicon compounds are the 3,3'-bis(trimethoxy or triethoxy

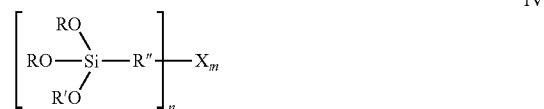
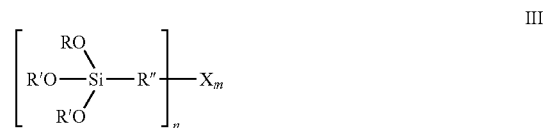
silylpropyl)sulfides. In one embodiment, the sulfur containing organosilicon compounds are 3,3'-bis(triethoxysilylpropyl)disulfide and 3,3'-bis(triethoxysilylpropyl)tetrasulfide. Therefore, as to formula II, Z may be



where R² is an alkoxy of 2 to 4 carbon atoms, alternatively 2 carbon atoms; alk is a divalent hydrocarbon of 2 to 4 carbon atoms, alternatively with 3 carbon atoms; and n is an integer of from 2 to 5, alternatively 2 or 4.

[0077] In another embodiment, suitable sulfur containing organosilicon compounds include compounds disclosed in U.S. Pat. No. 6,608,125. As disclosed in U.S. Pat. No. 6,608, 125, these sulfur containing organosilicon compounds are of the formula G-C(=O)—S—CH₂CH₂CH₂SiX₃ wherein each X is an independently selected RO-group wherein each R is independently selected from the group consisting of hydrogen, alkyl that may or may not contain unsaturation, alkenyl groups, aryl groups, and aralkyl groups, such moieties other than hydrogen having from 1 to 18 carbon atoms, and G is a monovalent alkyl of from 6 to 8 carbon atoms. In one embodiment, the sulfur containing organosilicon compounds includes 3-(octanoylthio)-1-propyltriethoxysilane, CH₃(CH₂)₆C(=O)—S—CH₂CH₂CH₂Si(OCH₂CH₃)₃, which is available commercially as NXT™ from GE Silicones.

[0078] In another embodiment, suitable sulfur containing organosilicon compounds include those disclosed in U.S. Patent Publication 2003/0130535. As disclosed in U.S. Patent Publication 2003/0130535, these sulfur containing organosilicon compounds are of the formulas III or IV

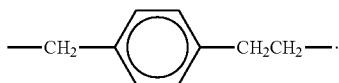


[0079] wherein: R is a methyl or ethyl group;

[0080] R' is identical or different and is a C₉C₃₀ branched or unbranched monovalent alkyl or alkenyl group, aryl group, aralkyl group, branched or unbranched C₂-C₃₀ alkyl ether group, branched or unbranched C₂-C₃₀ alkyl polyether group or R'''₃Si, where R''' is C₁-C₃₀ branched or unbranched alkyl or alkenyl group, aralkyl group or aryl group, R'' is a branched or unbranched, saturated or unsaturated, aliphatic, aromatic or mixed aliphatic/aromatic divalent C₁-C₃₀ hydrocarbon group;

[0081] X is SH where n=1 and m=1, S where n=2 and m=1-10 and mixtures thereof, S(C=O)—R''' where n=1 and m=1 or H where n=1 and m=1;

[0082] R" may mean CH₂, CH₂CH₂, CH₂CH₂CH₂, CH₂CH₂CH₂CH₂, CH(CH₃), CH₂CH(CH₃), C(CH₃)₂, CH(C₂H₅), CH₂CH₂CH(CH₃), CH₂CH(CH₃)CH₂ or



In one embodiment, the sulfur containing organosilicon compound is of formula III, R is ethyl, R' is C₁₂-C₁₄ alkyl, R" is CH₂CH₂CH₂, X is SH, n is 1 and m is 1. In one embodiment, the sulfur containing organosilicon compound is Si-363 from Degussa.

[0083] The amount of the sulfur containing organosilicon compound in a rubber composition will vary depending on the level of other additives that are used. Generally speaking, the amount of the compound will range from 0.5 to 20 phr. In one embodiment, the amount will range from 1 to 10 phr.

[0084] It is readily understood by those having skill in the art that the rubber composition would be compounded by methods generally known in the rubber compounding art, such as mixing the various sulfur-vulcanizable constituent rubbers with various commonly used additive materials such as, for example, sulfur donors, curing aids, such as activators and retarders and processing additives, such as oils, resins including tackifying resins and plasticizers, fillers, pigments, fatty acid, zinc oxide, waxes, antioxidants and antiozonants and peptizing agents. As known to those skilled in the art, depending on the intended use of the sulfur vulcanizable and sulfur-vulcanized material (rubbers), the additives mentioned above are selected and commonly used in conventional amounts. Representative examples of sulfur donors include elemental sulfur (free sulfur), an amine disulfide, polymeric polysulfide and sulfur olefin adducts. In one embodiment, the sulfur-vulcanizing agent is elemental sulfur. The sulfur-vulcanizing agent may be used in an amount ranging from 0.5 to 8 phr, alternatively with a range of from 1.5 to 6 phr. Typical amounts of tackifier resins, if used, comprise about 0.5 to about 10 phr, usually about 1 to about 5 phr. Typical amounts of processing aids comprise about 1 to about 50 phr. Typical amounts of antioxidants comprise about 1 to about 5 phr. Representative antioxidants may be, for example, diphenyl-p-phenylenediamine and others, such as, for example, those disclosed in *The Vanderbilt Rubber Handbook* (1978), pages 344 through 346. Typical amounts of antiozonants comprise about 1 to 5 phr. Typical amounts of fatty acids, if used, which can include stearic acid comprise about 0.5 to about 3 phr. Typical amounts of zinc oxide comprise about 2 to about 5 phr. Typical amounts of waxes comprise about 1 to about 5 phr. Often microcrystalline waxes are used. Typical amounts of peptizers comprise about 0.1 to about 1 phr. Typical peptizers may be, for example, pentachlorothiophenol and dibenzamido diphenyl disulfide.

[0085] Accelerators are used to control the time and/or temperature required for vulcanization and to improve the properties of the vulcanizate. In one embodiment, a single accelerator system may be used, i.e., primary accelerator. The primary accelerator(s) may be used in total amounts ranging from about 0.5 to about 4, alternatively about 0.8 to about 1.5, phr. In another embodiment, combinations of a primary and a secondary accelerator might be used with the secondary accelerator being used in smaller amounts, such as from about 0.05 to about 3 phr, in order to activate and to improve the

properties of the vulcanizate. Combinations of these accelerators might be expected to produce a synergistic effect on the final properties and are somewhat better than those produced by use of either accelerator alone. In addition, delayed action accelerators may be used which are not affected by normal processing temperatures but produce a satisfactory cure at ordinary vulcanization temperatures. Vulcanization retarders might also be used. Suitable types of accelerators that may be used in the present invention are amines, disulfides, guanidines, thioureas, thiazoles, thiurams, sulfenamides, dithiocarbamates and xanthates. In one embodiment, the primary accelerator is a sulfenamide. If a second accelerator is used, the secondary accelerator may be a guanidine, dithiocarbamate or thiuram compound.

[0086] The mixing of the rubber composition can be accomplished by methods known to those having skill in the rubber mixing art. For example, the ingredients are typically mixed in at least two stages, namely, at least one non-productive stage followed by a productive mix stage. The final curatives including sulfur-vulcanizing agents are typically mixed in the final stage which is conventionally called the "productive" mix stage in which the mixing typically occurs at a temperature, or ultimate temperature, lower than the mix temperature(s) than the preceding non-productive mix stage (s). The terms "non-productive" and "productive" mix stages are well known to those having skill in the rubber mixing art. The rubber composition may be subjected to a thermomechanical mixing step. The thermomechanical mixing step generally comprises a mechanical working in a mixer or extruder for a period of time suitable in order to produce a rubber temperature between 140° C. and 190° C. The appropriate duration of the thermomechanical working varies as a function of the operating conditions, and the volume and nature of the components. For example, the thermomechanical working may be from 1 to 20 minutes.

[0087] The rubber composition may be incorporated in a variety of rubber components of the tire. For example, the rubber component may be a tread (including tread cap and tread base), sidewall, apex, chafer, sidewall insert, wirecoat or innerliner. In one embodiment, the compound is a tread.

[0088] The pneumatic tire of the present invention may be a race tire, passenger tire, aircraft tire, agricultural, earth-mover, off-the-road, truck tire, and the like. In one embodiment, the tire is a passenger or truck tire. The tire may also be a radial or bias.

[0089] Vulcanization of the pneumatic tire of the present invention is generally carried out at conventional temperatures ranging from about 100° C. to 200° C. In one embodiment, the vulcanization is conducted at temperatures ranging from about 110° C. to 180° C. Any of the usual vulcanization processes may be used such as heating in a press or mold, heating with superheated steam or hot air. Such tires can be built, shaped, molded and cured by various methods which are known and will be readily apparent to those having skill in such art.

[0090] The runflat tire containing the inserts of this invention can be built, shaped, molded and cured by various methods that will be readily apparent to those having skill in the art.

[0091] While certain representative embodiments and details have been shown for the purpose of illustrating the invention, it will be apparent to those skilled in this art that various changes and modifications may be made therein without departing from the spirit or scope of the invention.

What is claimed is:

1. A pneumatic runflat tire comprising a sidewall insert, the sidewall insert comprising an axially layered thermoplastic.

2. The pneumatic runflat tire of claim 1, wherein the thermoplastic is selected from the group consisting of polyethylene, polypropylene, polyamide, polyester, polyphenylene ether, and polyphthalamide.

3. The pneumatic runflat tire of claim 1, wherein the thermoplastic is polyethylene.

4. The pneumatic runflat tire of claim 1, wherein the sidewall insert further comprises an adhesive selected from the group consisting of an RFL adhesive and an epoxy-based adhesive.

5. The pneumatic runflat tire of claim 1, wherein the sidewall insert comprises a plurality of thermoplastic layers.

6. The pneumatic runflat tire of claim 1, wherein the sidewall insert comprises a plurality of thermoplastic layers, wherein the thermoplastic layers have a layer thickness ranging from 0.1 to 1 mm.

7. The pneumatic runflat tire of claim 1, wherein the sidewall insert comprises at least 10 axially layered thermoplastic layers.

8. The pneumatic runflat tire of claim 1, wherein the sidewall insert comprises a plurality of thermoplastic layers, wherein an adhesive is disposed between the thermoplastic layers.

9. The pneumatic runflat tire of claim 1, wherein the sidewall insert comprises at least 10 axially layered thermoplastic layers, wherein an adhesive is disposed between the thermoplastic layers.

10. A method of making a pneumatic runflat tire, comprising the steps of

applying one or more tire components to a tire building machine; and

applying a plurality of layers of a thermoplastic to the one or more components to form an axially-layered thermoplastic runflat insert.

11. The method of claim 10, wherein the thermoplastic is selected from the group consisting of polyethylene, polypropylene, polyamide, polyester, polyphenylene ether, and polyphthalamide.

12. The method of claim 10, wherein the thermoplastic is polyethylene.

13. The method of claim 1, wherein the sidewall insert further comprises an adhesive selected from the group consisting of an RFL adhesive and an epoxy-based adhesive.

14. The method of claim 1, wherein the sidewall insert comprises a plurality of thermoplastic layers.

15. The method of claim 1, wherein the sidewall insert comprises a plurality of thermoplastic layers, wherein the thermoplastic layers have a layer thickness ranging from 0.1 to 1 mm.

16. The method of claim 1, wherein the sidewall insert comprises at least 10 axially layered thermoplastic layers.

17. The method of claim 1, wherein the sidewall insert comprises a plurality of thermoplastic layers, wherein an adhesive is disposed between the thermoplastic layers.

18. The method of claim 1, wherein the sidewall insert comprises at least 10 axially layered thermoplastic layers, wherein an adhesive is disposed between the thermoplastic layers.

19. A pneumatic runflat tire made by the method of claim 10.

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